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E-waste Management in India: A Literature Perspective

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Mumbai ranks first in terms of electronic waste generation inside the country of India.The administration and handling of electronic garbage, however, has not received the necessary attention. The government is in charge of developing and enforcing the required laws and regulations for properly handling e-waste. When comparing regions within India, the northern region states produce the most of the country's e-waste. It has been discovered that there are several e-waste processing facilities spread around Delhi.The research examines the e-squander management procedure in northern Indian states since those areas of the country are where the majority of the country's significant e-trashprocessing procedures are carried out. The volume of e-waste has increased significantly as a result of the frequent illicit import of e-waste into several developing countries, including India. Because e-waste contains precious materials like gold, copper, and aluminum, illegal tactics are being used. Industries are recycling materials using informal methods while oblivious to the existence of dangerous materials alongside profitable ones.The people who labour in these rudimentary recycling facilities as well as the environment are being harmed by these dangerous substances. It is important to use efficacious strategies in order to enhance public consciousness about the dangers linked to electronic garbage (e-waste) and to educate individuals on the appropriate means of disposing electronic gadgets, as opposed to just discarding them in conventional waste receptacles.

Arya et al. (2023) A recent source of solid garbage is called "e-waste" or "electronic waste." It includes precious and dangerous commodities that require specific handling for sound management of environment and recovery of precious assets as well. In developing countries like India, utmost e-squander finds their path through unofficial route posing substantial risks to both the environment and people. However in case of developed countries this situation is totally different where e-waste is either managed by formal channels or exported to poor countries. For this reason, authors decided to identify the loop holes in e-waste management policies in India by comparing them with the developed countries policies. Authors identified 8 factors for the comparison from the extensive study of literature. They compared Indian e-waste management policies with UN, UK, Germany, Japan, China and Kenya policies. With the help of this study, the authors have been capable to elaborate the advantages and limitations of e-waste management systems adopted by developed countries along with the current situation in India. This study found that although India has regulations for managing e-waste, they are not properly put into practice since there is no monitoring mechanism in place.

The bulk of responsibilities related to the handling of electronic trash, including collection, sorting, transportation, and recycling, are executed with minimal safety precautionsand generally using screwdrivers and hammers in India's informal recycling industry, as depicted in Figure 1. Additionally, because they are ignorant of the negative impacts of e-trash, safety precautions and human health issues are not a priority for them. E-waste is being segregated in working and dead equipment; re-useable gadgets find their way to second hand products market. Non-working items are next deconstructed or disassembled to identify the reusable components. Parts with less market value are burned in the open areas in order to recover the precious metals and non-metals.

Figure 1: Handling (Land-filing) of E-waste in Informal Recycling Unit (Source- istockphoto.com/Lya_Cattle)

End users, retailers, exporters, recyclers, producers or manufacturers, and disassemblers or dismantlers are the primary participants in the supply chain for e-waste. Even while e-waste is a growing issue, it also presents a significant potential for businesses given the volume of e-scrap created and the fact that it includes valuable elements. Gold, silver, copper, iron, aluminum, and other valuable metals make up approximately 60% of the total weight of e-waste's precious materials, while pollutants make up the remaining 2.70 percent (Widmer et al., 2005). Therefore, the process of recycling e-scrap is crucial for recovering valuable materials as well as from a waste management standpoint.

In the common e-squander retrieving system the End of Life (EOL) gadgets are collected and directed to a dismantler (Huisman *et al.*, 2007). At the dismantler's workplace, an assessment is made whether the product is more valuable if recycled or resold. If the product has some use value, it is directed either to a refurbisher, remanufacturer or the reseller. The complete product for resale is prepared by the refurbishers and the resellers while remanufacturers extract and resell the reusable components.

If a discarded electronic product is not usable, it is dismantled in numerous recoverable commodities. The hazardous constituents are generally moved to exact waste-processing facilities and the valuableconstituents are segregated into particular commodity streams. In the process of separation, two or more shredders are generally present to generate a more controllable sized materials for further handling in the magnetic separator and in eddy current separator. To attain an effective material separation, for recovering the valuable elements, recyclers generally utilize additional machinery (Sodhi and Reimer, 2001). Establishments which receive huge products, such as large appliances, pay less attention towards the resources. They precisely distinguish from the most available resources like steel and perform an easy process to segregate it from the rest during initial processing (Ferrao and Amaral, 2006).After product segregation, the metal streams are directed to the smelters whereas plastics and other commodities move to refiners, incinerators or landfills.

Despite being the world's fifth greatest generator of E-waste, India lags significantly behind Germany, Switzerland, and Japan in terms of E-squander recycling, according to the report. The contribution of this research is to extract the best strategies used in countries that thrive in E-waste management and to discuss their implications in the Indian context. This research is directed at all stakeholders, but particularly policymakers and manufacturers, who are responsible for examining the issue of e-scrap. For the proper execution of e-squander rules, Indian authorities involved in the system should prioritize the enhancement of human, financial, and technological resources. It is necessary to establish a separate authority for e-scrap in order to efficiently handle e-squander and to relieve already stressed PCBs. Furthermore, rules must be updated to reflect the current situation in India. In the same way as municipalities in Germany are responsible for collecting on behalf of individual producers, PROs in India can collect on their behalf. PROs should be registered by all producers, importers, and manufacturers. The "distributed informal collectors" must be a part of any formal collection method. Initially, the collection stations in Switzerland were retail outlets and transporter's logistical hubs. Because of their extensive coverage, merchants were the most practical and cost-effective option, and they acted as a conduit between the consumer and the producer. Additionally, it provided shops with the option to expand their consumer base by swapping old products for new ones. Retailers must be assigned primary duty for collecting E-waste and spreading awareness in India as well. ARF is a better alternative than DRS because it acts as a deposit for future E-waste management. It also adheres to the polluter pays concept, as environmental costs are internalised in the product price. The visible cost also creates a fair playing field for all producers and

retailers, making price competition on recycling fees impossible. In Switzerland, extra collection terminals were constructed at key locations such as train stations and community collection centres to address issues of low collection rates related to the reluctance of consumers to engage in disposal activitiesof outdated products. The reason for the limited accessibility to retailer outlets is primarily attributed to geographical remoteness. More collecting terminals should be established in important locations in India, such as shopping malls and metro stations. Despite the potential for individual resistance, it is imperative for India to prioritise the advantages of a collective system, as it enables economies of scale and fosters a consumer-centric approach.It is imperative that legislation mandates consumers to responsibly dispose of their electronic trash (E-waste) through the implementation of an Extended Producer Responsibility (EPR) framework. It is imperative for India to prioritise the enhancement of consumer awareness and environmental stewardship, with the implementation of effective waste segregation practises prior to disposal.

The producers' major job, like in Switzerland, is to report their sales data and send the advanced recycling feecollected to the recycling firms.

In India, a similar approach is required. Before E-waste rules were enacted in Japan, recycling factories were already in place. Lack of formal framework is a key impediment to successful electronics garbage recycling. Research &Development should be conducted to establish nativeunits for the environmentally friendly extraction of valuable metals from electronic trash.The assessment of the recycling rate should be conducted with consideration for component reuse or material recycling, as exemplified by the practises in Japan. India should join Japan's "Design for Environment (DOE)" movement. DOE includes voluntary producer practices such as design for ease of recycling, use of easy-to-recycle materials, and Research and development (R&D) efforts are being directed towards the development of environmentally sustainable design and production practises. These practises take into account the entire lifecycle of products, aiming to efficiently recover materials from waste. By doing so, the costs associated with final disposal are reduced. This benchmarking experiment demonstrates how the radar chart approach may be used to compare the performance indicators of e-trash reprocessing systems. (Chaudhary, 2018)

According to Heeks et. al (2015) formal recycling of e-trash is becoming more of a challenge in underdeveloped nations, one that, if not addressed, could jeopardise the long-term viability of ICT use. The authors focused on a group that significantly contributes to e-trash in developing countries: local organisational ICT consumers. Despite the prevailing circumstance that this particular demographic is responsible for the majority of electronic waste (e-waste) production, there exists a dearth of knowledge regarding the determinants that shape their decision-making processes pertaining to e-waste. As a result, this research draws on the environmental management literature to develop imaginary models of e-trash strategies. It applies these models to India's ICT services sector, which generates a significant amount of e-waste.The previous entity has demonstrated a proactive approach in their management of electronic trash, whereas small and medium-sized enterprises are often characterised as indifferent towards e-waste. This discrepancy can be attributed to the diverse array of influential circumstances that SMEs encounter, each with varying degrees of impact. These characteristics, in turn, are related to the size of these ICT customers as well as the type of the value chains in which they are embedded. The identified drivers are helpful in planning better e-scrap initiatives, as seen by a recent bill that was just submitted.

Khaiwal et al. (2019) highlighted the growth of the electronic sector, as well as the faster speed of technological change, has resulted in massive amounts of WEEE. This study examines the emergence of electronic garbage (E-waste) and its treatment approaches in Chandigarh, India, through the utilisation of a standardised questionnaire and a physical survey conducted on 300 households representing diverse socioeconomic backgrounds. The results from these families were extrapolated to represent the entire Chandigarh population. The kind and amount of e-gadgets in each household were recorded to create an E-waste inventory. According to the results of the survey, just 30% of respondents are aware of E-waste and the dangers it poses to the environment. Furthermore, just 10% of respondents knew where E-waste collection containers could be found in the city, and only 2% of those who knew where they might be found were using them. Additionally, it was found that the average quantity of electronic garbage (E-waste) produced by each family in Chandigarh is 17 kg per year, leading to a cumulative annual generation of 4100 tonnes of E-waste from all households in Chandigarh. The proportion of precious metals in E-trash makes urban mining an effective e-garbagereprocessing option in Chandigarh. E-trash created in Chandigarh has the potential to reimburse benefits of more than $65,000 each year. The study also makes recommendations for improving E-waste collection for long-term recycling.

Shirodhar (2017) explained the retrieval of raw materials from waste is a crucial component of sustainable production.E-Waste is one of the world's most dangerous and rapidly expanding waste issue. Developing countries, such as India, are at higher risk as a result of illegal imports and rising local e-squander output, as well as a lack of regulations and legislation governing e-waste handling. 90 percent of India's million tonnes of e-waste is thrown by informal recyclers who employ primitive processing methods, polluting the air,

water, and ground. Safe disposal is an important aspect in sustainable manufacturing, and e-scrap is the resultant outcome of the large-scale production of electronic items, it is critical to dispose of it securely. This study examines the current state of e-squanderreprocessing in India, as well as its consequences, and proposes a new, unique management model as the best option for e-waste management in India. Instead of diminishing employment in the informal sector, the Stepped Recycling strategy effectively addresses the problem of e-waste management by achieving environmentally friendly means of recycling. This industry has the potential to expand into a big economic sector, but it will require innovation in improved recycling and disposal technologies. The present methodology exhibits a high degree of adaptability towards the aforementioned developments, hence fostering their implementation through the inclusion of private sector engagement in the realm of e-waste recycling.

Dwivedi (2015) studied the issue of rising e-waste volumes in developing nations has driven governments to devise novel control mechanisms and institutionalise environmentally friendly ways to counteract the dangers posed by such trash. In India, the practise of recycling electronic trash (e-waste) has conventionally operated under a market-driven framework. Producers are anticipated to promptly embrace and implement Extended Producer Responsibility (EPR) frameworks in accordance with the recently formulated legislation governing the management and handling of electronic waste in India. In these instructions, the scope of applying EPR is also explored. In this paper, we attempt to evaluate several EPR take-back schemes and determine their applicability for Indian conditions. To determine the profitability of various EPR take-back systems, we employ an economic model. The overall financial viability of the e-waste take-back initiative plays a crucial role in the effectiveness of any e-waste recycling policy, as it is necessary for covering the additional costs associated with e-waste recycling. The findings of our simulation clearly reveal that an individual take-back scheme outperforms a communal take-back plan from the standpoint of both consumers and producers. The effects and implications of different take-back strategies on the model parameters of interest are also discussed. Because of the unique character of the recycling industry in India, where customers expect financial rewards when disposing of e-trash, The EPR paradigm employed in industrialised nations is prone to failure due to its imposition of costs on consumers. The goal of this study was to get a better understanding of how such market conditions would affect an EPR model. To compare two distinct approaches of collecting EOL results, an analytical framework was proposed and studied. The study reveals critical findings that will have far-reaching implications for future legislation, particularly in determining which take-back method is most suited to the Indian situation. The results of the study demonstrate a mutually beneficial outcome for both consumers and the business sector. Manufacturers who embrace a collective take-back plan will see their profit margins shrink as product prices rise. Because of the various types of products, the gathered items must be separated before they can be recycled in the communal case. In the individual case, this additional fee is not existent. These findings largely contradict the findings of other writers who sought to replicate various take-back programmes in the context of industrialised countries, but their focus was on allocating collected end-of-life products to recyclers rather than delving into the specifics of each take-back scheme. Another important distinction is that the proposed model expressly included the practise of compensating consumers for their used items during the collection process, as observed in India, is a tangible manifestation of this principle.

Conclusion:

Majority of the tasks associated with processing of e-trash like collection, dismantling, segregation, transportation are carried out manually and by informal sector in India. E-waste is not only the abundant source of recyclable material but also the source of income for thousands of people in India. A large section of Indian population (rag pickers) depends on the waste materials like plastics, polythene bags etc for their livelihood.The recycling industry of electronic trash also involves the participation of child labor.They collect and sell it to localized scrap dealers and it is the only source of income for them.The individuals in question lack awareness about the detrimental impacts of e-trash on both health of human being and the surroundings. They have not been provided with the modern safety equipment required during the safe disposal of e-trash.

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